Alarm Management

by

David Walker

Technical Services Manager,

Yokogawa Australia

Alarm Management

- What is an alarm?
- Objectives of a good alarm system
- Alarm system design
- Alarm reduction
- Advanced alarm techniques

Case Study – Kegworth Air Disaster

- 8 January 1989
- British Midland 737
- Heathrow – Belfast

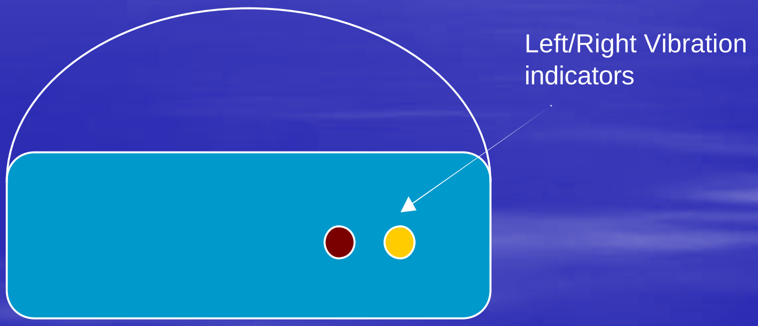
- Engine failure after take off.
- Crashed when trying to land at East Midland airport.

Case Study – Kegworth Air Disaster

- Chronology of events
  - Fan blade ruptured in left engine, causing vibration and smoke to enter cabin.
  - Pilot incorrectly identified right engine as failed.
  - Pilot shut off right engine. Vibration and smoke ceased and everything seemed ok.
  - On approach to airport, more fuel was pumped to left engine and it failed completely.

Case Study – Kegworth Air Disaster

- Why did the pilot miss-identify the failed engine?



1. Ergonomics

   Both vibration indicators on right hand side of the cockpit. Under stress, the pilot saw the left engine vibration indicator but thought it referred to the right engine.

Case Study – Kegworth Air Disaster

- Why did the pilot miss-identify the failed engine?

2. Confidence in sensor information

   Vibration sensors were known to be unreliable and therefore not usually used for diagnostics. Therefore not careful attention was paid to the instrumentation.

Case Study – Kegworth Air Disaster

- Why did the pilot miss-identify the failed engine?

3. Coincidence of events

   Switching off the right engine caused less fuel to flow to the left engine, thereby reducing vibration and smoke. This appeared to confirm their assumption that the right engine had failed.

Case Study – Kegworth Air Disaster

- Why did the pilot miss-identify the failed engine?

4. Inexperience and lack of training

   The pilots were inexperienced with the newly released 737-400 and were not properly trained on the differences with the older 737s.

Case Study – Kegworth Air Disaster

- What lessons are there for control systems engineers?

1. Properly designed alarm system
2. Properly functioning instrumentation
3. Sufficient training on any newly implemented system

What is an alarm?

An alarm is a report of an abnormal process event that requires an operator to take action.

What is an alarm?

- Categories of alarms:
  - Safety – catastrophic failure, loss of life
  - Operational – plant or equipment failure/trip
  - Information – process inefficiencies

Objectives of a good alarm system

- Presents only useful & relevant alarms
- Each alarm should have a defined response
- Clearly identifies the problem
- Allows adequate time for response
  - Frequency: < 6 alarms per hour, steady state
< 60 alarms per hour, plant upset

Alarm System Design

- General
  - Design alarm strategy before configuration commences
  - Create rules for assigning priorities
  - Consider system defaults

Alarm System Design

- Considerations in alarm design
  - Purpose of the alarm
  - Response required by the operator
  - Consequences of not responding to the alarm
  - Time required for the operator to respond
  - Effectiveness of operator response

Alarm System Design

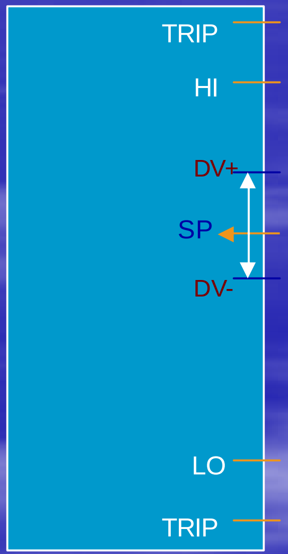
- What should **not** be an alarm
  - Events that do not require an operator response
  - Events that an operator cannot respond to
  - Confirmation of actions taken by the operator
  - Duplicate signals

Alarm System Design

- Control System Defaults
  - All function blocks have enabled alarms
  - All alarm types for each block enabled
  - All alarm priorities set to Medium

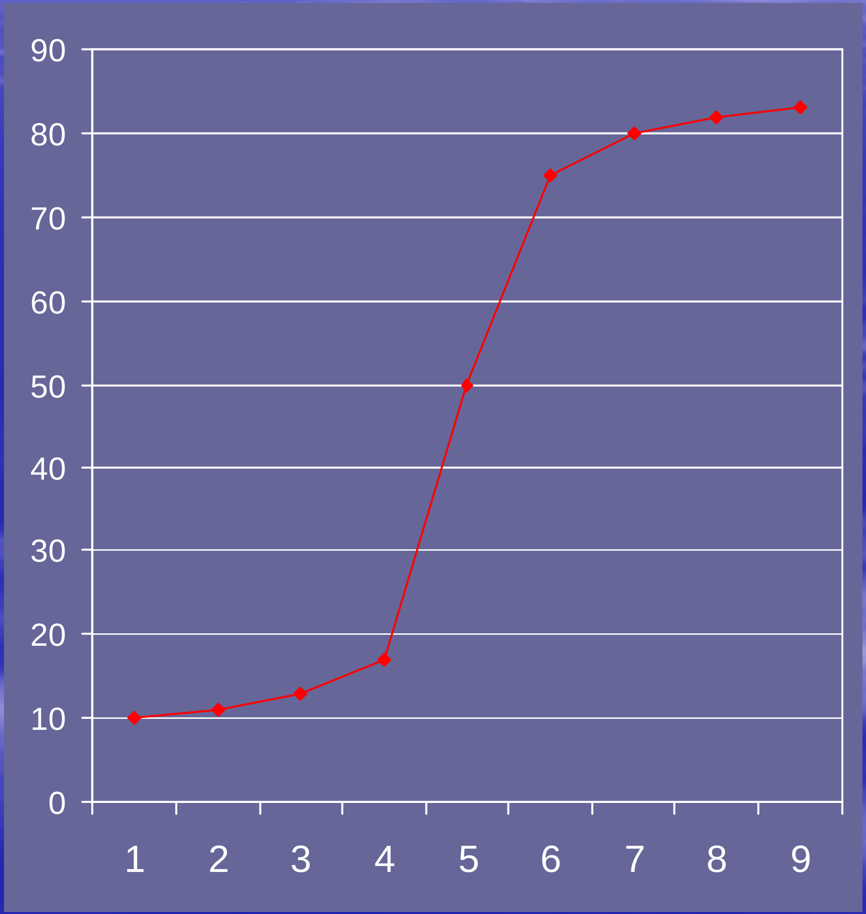
Alarm System Design

- Alarm types
  - – Absolute: eg, high/low alarms
    - Simple ✓
    - Inflexible ✗
  - – Deviation: deviation of PV from setpoint
    - Must be suppressed during plant disturbance



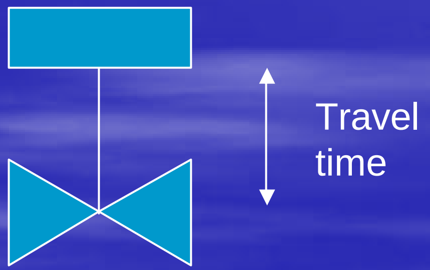
Alarm System Design

- Alarm types
  - Rate of change
    - Predictive ✓
    - Susceptible to noise ✗



Alarm System Design

- Alarm types
  - – Discrepancy Alarms
    - Motor/valve travel time
    - Degradation of equipment can lead to spurious alarms ✘



Alarm System Design

- Alarm types
  - Retriggering alarms
    - Re-alarm if alarm not cleared after a period of time.
  - Calculated alarms
    - Powerful & flexible
    - Possible with modern control systems
    - Dynamic alarm parameters

Alarm System Design

- Alarm Priority
  - Determined by:
    - severity of consequences
    - and time taken to take action
  - Priority bands: Maximum 4
    - Critical (in safety system only)
    - High
    - Medium
    - Low
    - Logging (does not count in the maximum number of bands)

Create a set of rules to determine alarm priority to ensure consistency of alarm response.

Alarm System Design

- Alarm Priority

Example 1

Priority	Safety Risk	Economic Loss	Environmental Risk
Critical	> 0.1	> $100,000	> 0.1
High	> 0.01	> $10,000	> 0.01
Medium	> 0.001	> $1,000	> 0.001
Low	< 0.001	< $1,000	< 0.001

Example 2

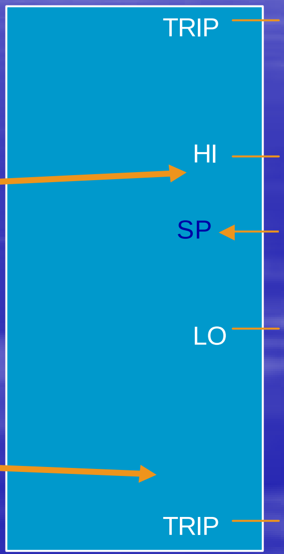
Priority	Operational
Critical	Total loss of plant
High	Loss of plant area
Medium	Loss of equipment → loss of production
Low	Loss of equipment without loss of production

Alarm System Design

- Alarm Priority
  - Alarm priorities provide ways of presenting alarms of different levels of importance to the operator:
    - Audible tone
    - Colour
    - Acknowledgment requirements

Alarm System Design

- Alarm Settings
  - Absolute:
    - Within normal operating range
      - Spurious alarms occur during plant fluctuation
      - Too high an alarm rate for the operator
    - Settings near trip limits
      - Less spurious alarms
      - But not enough time to respond to alarm events
      - Less safe as it relies to heavily on safety trips
    - Redesign plant or control system for greater margin between normal operating limits and trip limits
      - Expensive and difficult to achieve



Alarm System Design

- Summary
  - Design alarm strategy:
    - Performance Objective
    - Priority allocation rules
    - Rules for determining critical alarms (to be handled by safety system)
    - Design of alarm interface to operator
    - Alarm configuration
      - Setpoints
      - Hysteresis
    - Rules and policies for alarm suppression
    - Change management
    - Alarm review management and policy

Alarm Reduction

- Field Sensors
  - Proper selection
  - Proper installation
  - Proper calibration
  - Maintenance

Consequences:

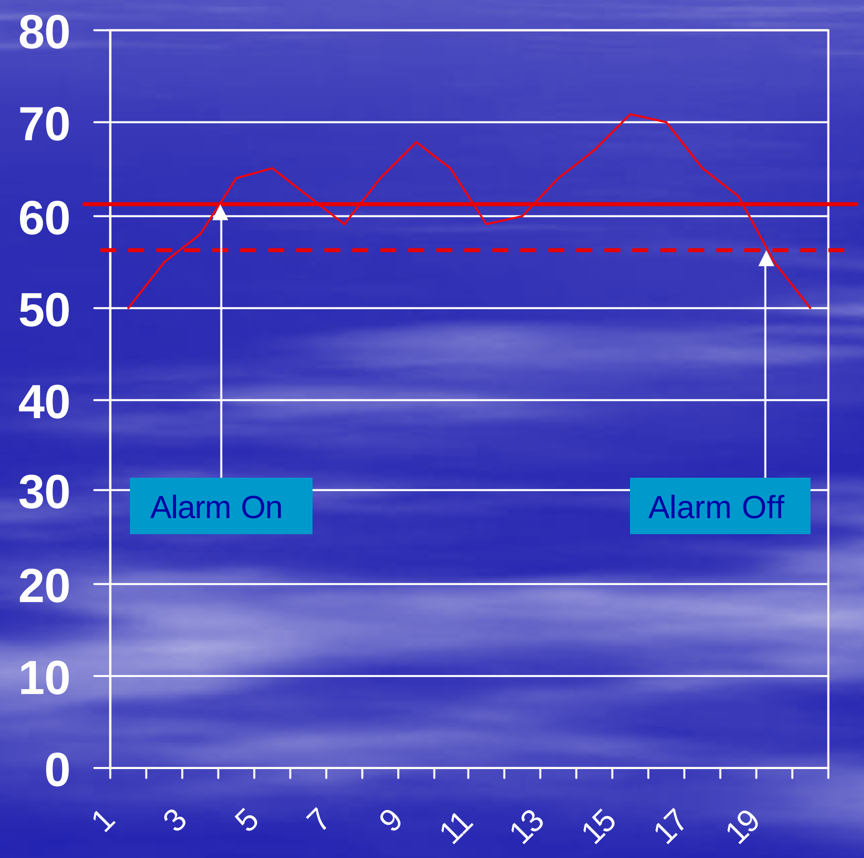
- Incorrect values → spurious alarms or lack of confidence in information
- Device failure
- Chattering
- “Garbage in – Garbage out”

Alarm Reduction

- Input Processing
  - Filter inputs to eliminate noise that can cause chattering
  - Debouncing of contact inputs

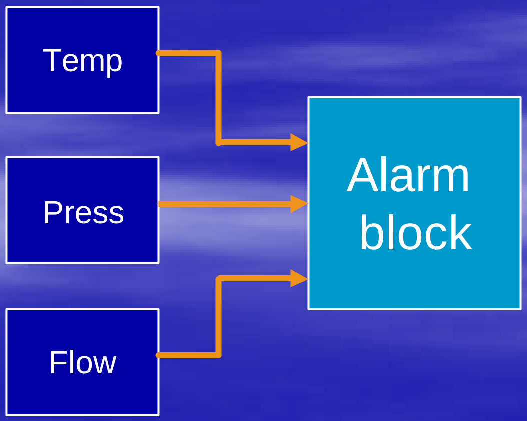
Alarm Reduction

- Hysteresis
  - Deadband around alarm setpoint to prevent chattering.



Alarm Reduction

- Grouping
  - Group alarms of signals related to a piece of equipment into one alarm
  - Direct operator to graphic that provides detailed information on the equipment in alarm



Alarm Reduction

- Dynamic Masking
  - Logic in controller that suppresses (masks) alarms due to process conditions
  - Examples:
    - Pump not running – do not alarm on low flow
    - Pump starting – do not alarm on high current
    - Device failure – suppress related alarms
    - Plant start up/shut down

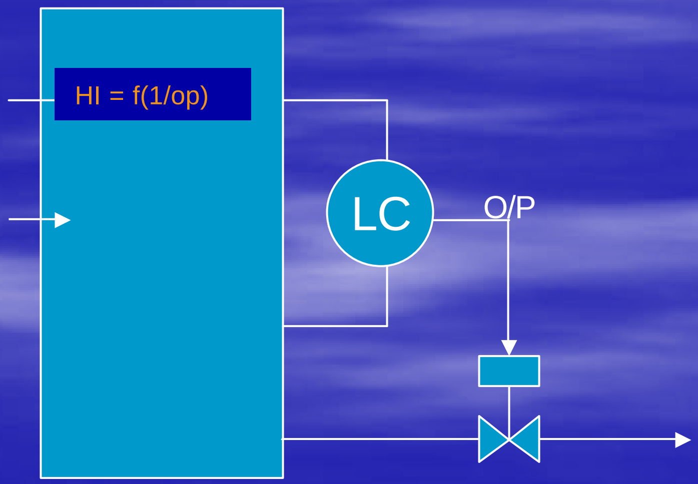
Alarm Reduction

- Dynamic Alarm Setting
  - Vary absolute alarms (High/Low) as a function of a process value

Example: high level alarm

If O/P is 100% then set High alarm limit low.

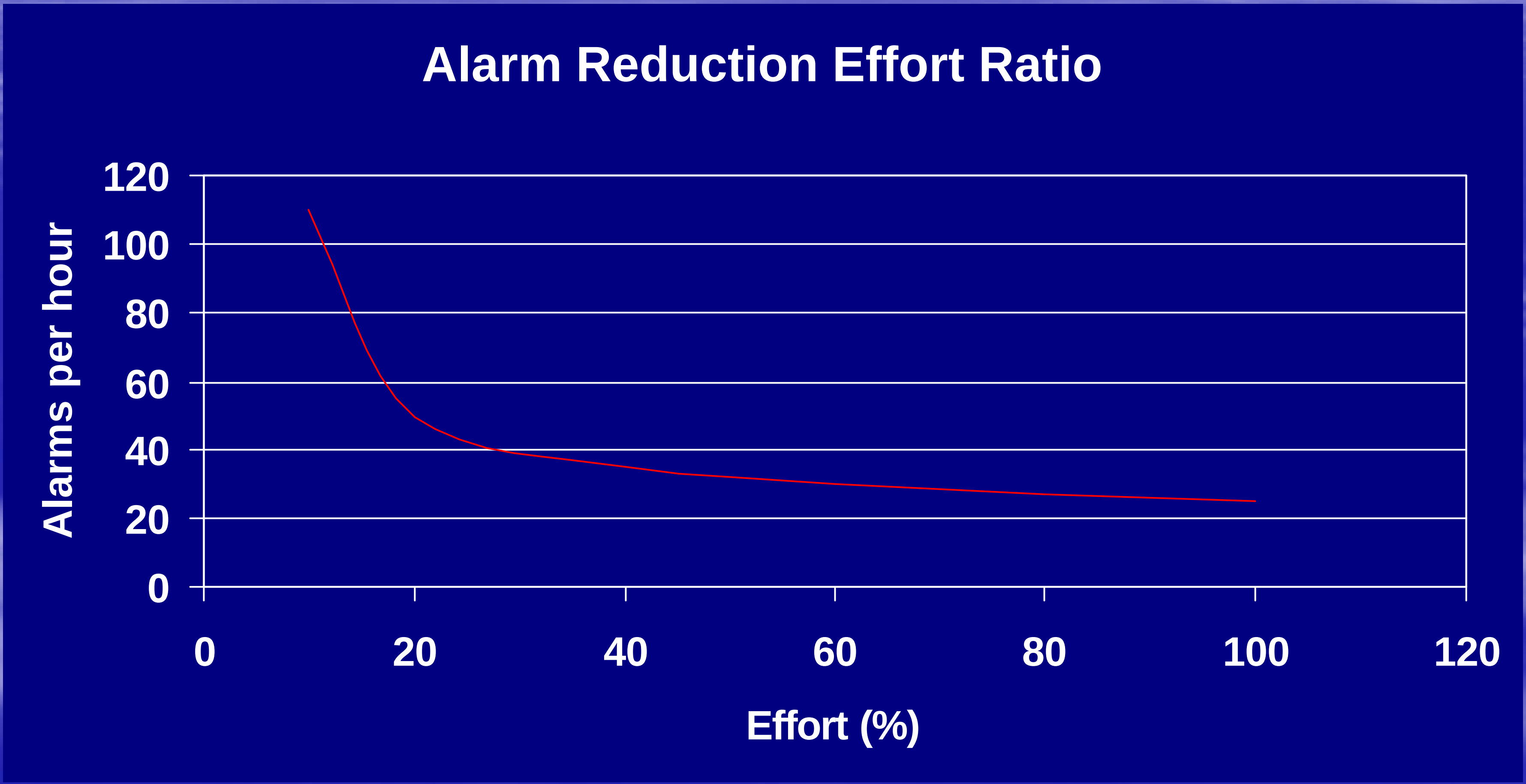
As O/P decreases, increase High alarm limit.



Alarm Reduction

- Filtering
  - Category
    - Plant area
    - Process area
    - Equipment, etc
  - Priority
  - Unacknowledged alarms
  - Tagname(s)
  - Controller(s)
  - Plant mode

Alarm Reduction



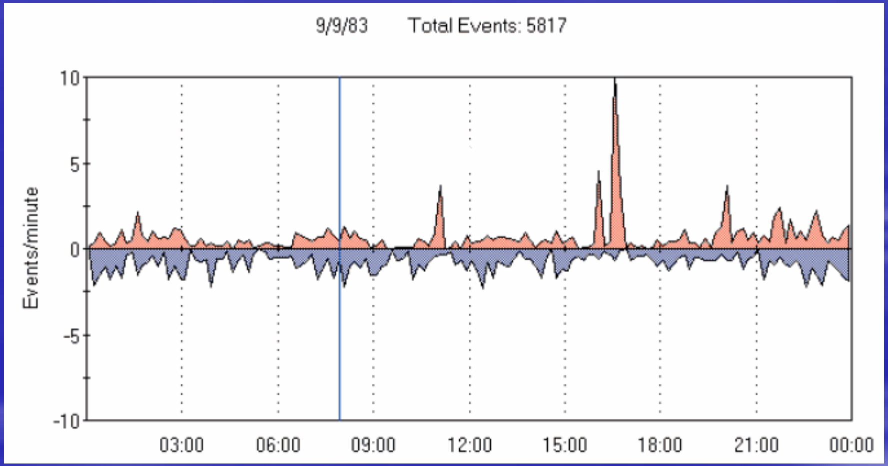
Advanced Techniques

- Alarm Frequency Analysis
  - – Determine highest frequency alarms.
  - – Very useful when used with correlation analysis

Matrikon – Process Guard

Advanced Techniques

- Correlation Analysis
  - Identification of repeating (chattering) alarms
  - Cross-correlation with other alarms
  - Cross-correlation with operator actions



Conclusion

- A well designed alarm system depends on:
  - Proper instrumentation
  - A well constructed alarm strategy
    - What is an alarm
    - Defined actions for each alarm
    - Priorities
    - Appropriate alarm settings
    - Dynamic alarm suppression
    - Good filtering tools

Conclusion

- A well designed alarm system provides:
  - Unambiguous information to the operator
  - Enough time for the operator to respond
  - Results in fewer trips and incidents

Recommended Reading

- Practical Alarm Management – IDC
- EEMUA Publication No. 191, Alarm Systems – A Guide To Design, Management and Procurement
- AS61508, Functional Safety of Electrical, Electronic, Programmable Electronic Safety Related System
- Managing Maintenance Error – A Practical Guide, A. Hobbs & A. Williamson (for aircraft maintenance)

Thank you!